Original Investigation

Visual Function, Social Position, and Health and Life Chances
The UK Biobank Study

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IMPORTANCE The adverse impact of visual impairment and blindness and correlations with socioeconomic position are known. Understanding of the effect of the substantially more common near-normal vision (mild impairment) and associations with social position as well as health and life chances is limited.

OBJECTIVE To investigate the association of visual health (across the full acuity spectrum) with social determinants of general health and the association between visual health and health and social outcomes.

DESIGN, SETTING, AND PARTICIPANTS A cross-sectional epidemiologic study was conducted using UK Biobank data from 6 regional centers in England and Wales. A total of 112 314 volunteers (aged 40-73 years) were assessed in June 2009 and July 2010. Data analysis was performed from May 20, 2013, to November 19, 2014.

MAIN OUTCOMES AND MEASURES Habitual (correction if prescribed) distance visual acuity was used to assign participants to 1 of 8 categories from bilateral normal visual acuity (logMAR, 0.2 or better; Snellen equivalent, 6/9.5 or better) to visual impairment or blindness (logMAR, 0.5 or worse; Snellen equivalent, 6/19 or worse) using World Health Organization and *International Statistical Classification of Diseases and Related Health Problems, Tenth Revision* taxonomy. Relationships between vision, key social determinants and health and social outcomes (including the main factors that define an individual's life—the social, economic, educational, and employment opportunities and outcomes experienced by individuals during their life course) were examined using multivariable regression.

RESULTS Of the of 112 314 participants, 61 169 were female (54.5%); mean (SD) age was 56.8 (8.1) years. A total of 759 (0.7%) of the participants had visual impairment or blindness, and an additional 25 678 (22.9%) had reduced vision in 1 or both eyes. Key markers of social position were independently associated with vision in a gradient across acuity categories; in a gradient of increasing severity, all-cause impaired visual function was associated with adverse social outcomes and impaired general and mental health. These factors, including having no educational qualifications (risk ratio [RR], 1.86 [95% CI, 1.69-2.04]), having a higher deprivation score (RR, 1.08 [95% CI, 1.07-1.09]), and being in a minority ethnic group (eg, Asian) (RR, 2.05 [95% CI, 1.83-2.30]), were independently associated with being in the midrange vision category (at legal threshold for driving). This level of vision was associated with an increased risk of being unemployed (RR, 1.55 [95% CI, 1.31-1.84]), having a lower-status job (RR, 1.24 [95% CI, 1.09-1.41]), living alone (RR, 1.24 [95% CI, 1.10-1.39]), and having mental health problems (RR, 1.12 [95% CI, 1.04-1.20]).

CONCLUSIONS AND RELEVANCE Impaired vision in adults is common, and even near-normal vision, potentially unrecognized without assessment, has a tangible influence on quality of life. Because inequalities in visual health by social position mirror other health domains, inclusion of vision in generic initiatives addressing health inequalities could address the existing significant burden of underrecognized and/or latent visual disability. Longitudinal investigations are needed to elucidate pathophysiologic pathways and target modifiable mechanisms.

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People value good eyesight. Blindness is known to have a broad-ranging adverse influence on affected individuals, their families, and the societies in which they live and is exemplified by its association with impaired quality of life, worse general and mental health, curtailed life chances, and increased all-cause mortality.[1-4] It is therefore unsurprising that international policies and research relating to ophthalmology and visual sciences have prioritized this end of the spectrum of impaired vision.[5-8] An unintended consequence of this prioritization is that less attention has been focused on the much larger population with mildly impaired or near-normal vision that also may affect activities of daily living.[9] Equally, this prioritization has created an underpinning conceptual framework for policy and research centered on the notion of visual impairment (VI) rather than on the concept of visual health (ie, the full continuum of visual function). This narrow focus contrasts with the broader health literature. Consequently, although socioeconomic correlates of VI and blindness are known, neither the social determinants of visual health per se nor the social determinants of inequalities in visual health have received the same attention as other health states.[10-13] Hence, evidence necessary for policy and service planning about the association between health and social outcomes and visual health is incomplete.

One obstacle to such research has been the unavailability of population samples of sufficient size and detail to enable robust interrogation of the full spectrum of visual function. We report what we believe to be a novel investigation of visual health in a contemporary adult population drawing on UK Biobank,[14] the largest prospective investigation of lifestyle and environmental determinants of health and disease. We hypothesized that key social determinants of health are associated with visual health and that visual health is associated with key general health and social outcomes. We further hypothesized that meaningful gradients of inequality exist in these associations.

Key Points

Question How is visual function across the full acuity spectrum ranging from near-normal vision to blindness associated with social position and health and social outcomes?

Findings In this study of a large national sample of UK adults with abnormal vision in 1 or both eyes, key indicators of social position were independently associated with abnormal vision across the full acuity spectrum, and impaired visual health was independently associated with adverse health and social outcomes in a gradient starting from near-normal vision.

Meaning The findings of this study indicate a significant burden of underrecognized and/or latent visual disability that might be addressed by including visual health within initiatives addressing general health inequalities.

Methods

Between February 2006 and July 2010, UK Biobank assessed 502 682 persons aged 40 to 73 years (identified from the electoral register) following individual written informed consent for participation; there was no financial compensation.[14] Diverse detailed data were collected through physical assessments, biological samples, and self-report on health and disease, including eyes and vision, using validated instruments. In 2009, an ophthalmic assessment was added to the main protocol and undertaken by 117 907 participants (23.5%) at 5 recruitment centers in England and 1 in Wales. This assessment comprised habitual distance visual acuity, refraction without cycloplegia (Tomey RC-5000 auto refkeratometer; Tomey Corporation), intraocular pressure measurement, fundus photography, and optical coherence tomography. The present study was conducted from June 2009 to July 2010.

UK Biobank has received approval from the North West Multi-Centre Research Ethics committee, which covers the United Kingdom. UK Biobank also obtained approval in England and Wales from the Patient Information Advisory Group for gaining access to information that would allow it to invite people to participate. The Patient Information Advisory Group has since been replaced by the National Information Governance Board for Health & Social Care. In Scotland, UK Biobank has received approval from the Community Health Index Advisory Group. The present study was approved by the National Information Governance Board for Health & Social Care, which allows access to information for inviting individuals to participate.

Classification of Visual Function

Distance visual acuity is the standard clinical measure of visual function and the basis of international taxonomies of VI. Within UK Biobank, habitual distance visual acuity in each eye (ie, tested with the individual wearing any prescribed, presently used optical correction) was measured to assess real-life visual function rather than best-corrected acuity as is often used in ophthalmic research. Individuals were assigned to 1 of 8 mutually exclusive visual function categories (**Table 1**)[15] based on acuity in the better-seeing eye (ie, at the level of the person rather than the level of the eye), given our interest in investigating risk factors and outcomes measured at the level of the person. Within both the World Health Organization's classification (based on the better-seeing eye) and *International Statistical Classification of Diseases and Related Health Problems, Tenth Revision*[16] (which also classifies unilateral vision in the worst-seeing eye), all individuals with visual acuity of 0.5 logMAR (Snellen equivalent, 6/19) or better are grouped together as having mild or no VI rather than being delineated as, for example, those not meeting thresholds for driving. Thus, we extended prior modification by our group[17] of the source World Health Organization classification comprising VI, severe VI (SVI), and blindness (blind) to allow our a priori analysis of the full spectrum of acuity as an ordered categorical variable by distinguishing normal vision from new categories of unilateral near-normal and bilateral near-normal vision and socially significant VI.

To specifically assess unrecognized or uncorrected refractive error as a potential cause of reduced habitual visual acuity in individuals without prescribed optical correction, we undertook subgroup analysis of associations between refractive error, self-report of optical correction, visual function, and sociodemographic and health variables. Spherical equivalent

Table 1. Distribution of Vision Function Categories by Age[a]

Descriptive Category in WHO Taxonomy[b]	Visual Function Category[c]	Participant Age, No. (%), y			
		40-49	50-59	60-73	Total
Mild or no visual impairment[d]	Bilateral normal 0-0.2 (Snellen equivalent, 6/6 to 6/9.5)	21 934 (85.5)	27 482 (77.5)	36 461 (71.7)	85 877 (76.5)
	Unilateral near normal 0-0.2 vs 0.21-0.3 (Snellen equivalent, 6/6-6/9.5 vs worse than 6/9.5-6/12)	1390 (5.4)	3063 (8.6)	5474 (10.8)	9927 (8.8)
	Bilateral near normal 0.21-0.3 (Snellen equivalent, worse than 6/9.5-6/12)	150 (0.6)	379 (1.1)	828 (1.6)	1357 (1.2)
	Unilateral VI 0-0.3 vs 0.31 or worse (Snellen equivalent, 6/12 or better vs worse than 6/12)	1788 (7.0)	4037 (11.3)	6652 (13.1)	12 477 (11.1)
	Socially significant VI[1] 0.31-0.49 (Snellen equivalent, worse than 6/12-6/18) in the better-seeing eye	237 (0.9)	599 (1.7)	1081 (2.1)	1917 (1.7)
VI and SVI (low vision)	VI 0.5-1.0 (Snellen equivalent, 6/19 to 6/60) in the better-seeing eye	136 (0.5)	213 (0.6)	378 (0.7)	727 (0.6)
	SVI 1.1-1.3 (Snellen equivalent, worse than 6/60 to 3/60) in the better-seeing eye	6 (0.02)	11 (0.03)	9 (0.02)	26 (0.02)
Blindness	Blindness 1.31 or worse in both eyes (Snellen equivalent, worse than 3/60 in both eyes)	4 (0.01)	2 (0.01)	0	6 (0.01)
Total		25 645 (22.8)	35 786 (31.9)	50 883 (45.3)	112 314 (100)

Abbreviations: SVI, severe visual impairment; VI, visual impairment; WHO, World Health Organization.

[a] Distribution of vision function by sex was the same as the overall distribution.

[b] Ratified taxonomies.[15]

[c] Habitual logMAR visual acuity.

[d] LogMAR, 0-0.49 in better-seeing eye (Snellen equivalent, 6/18 or better).

(SEQ) quantifies the refractive status of an eye in a single scale (algebraic sum in diopters [D], sphere +0.5 cylinder, and refraction measures). Using the mean SEQ of the 2 eyes, we categorized individuals as having emmetropia (SEQ, −0.99 to +0.99 D), myopia (SEQ, −1.0 D or less), or hypermetropia (SEQ, +1.0 D or more). The available demographic, socioeconomic, and health data and derived variables are reported in **Table 2**.

Eligibility and exclusion criteria applied to achieve the sample for analysis (eFigure 1 in the Supplement) included categorization or exclusion of individuals unable or unwilling to undergo acuity assessment, those ineligible for clinical reasons as prespecified in the UK Biobank protocol (https://biobank.ctsu.ox.ac.uk/crystal/refer.cgi?id=100250), and those lacking sufficient data on acuity for both eyes to allow categorization of visual status (eg, did not complete the test or tested in only 1 eye).

Statistical Analysis

Descriptive analysis of the distribution of visual function was based on all participants. Associations between visual function and sociodemographic factors were analyzed using the data set complete for visual function, demographic, socioeconomic, and health variables. Because of the small numbers within the groups (Table 1), the World Health Organization categories of VI (n = 727), SVI (n = 26), and blind (n = 6) (ie, logMAR 0.5 or worse; Snellen equivalent 6/19 or worse in the better-seeing eye) were combined.

To investigate the association of social determinants of general health with vision health (across the full acuity spectrum), multinomial analyses were undertaken with adjustment for confounders and comparison of each visual function category with the results of persons with bilateral normal vision. Robust SEs were used to account for clustering of individuals within test center.

Multivariable logistic and ordinal regression were used, as appropriate, to investigate associations between visual function and health and life chances (the social, economic, educational, and employment opportunities and outcomes experienced by individuals during their life course). Because the temporal relationship between impaired visual function, education, and social position is difficult to disentangle using the cross-sectional data available in UK Biobank, we undertook an additional subgroup analysis restricted to participants with higher educational attainment to investigate associations between visual function and social outcomes. Analyses were carried out using Stata, version 13 (StataCorp LP). Data analysis was performed from May 20, 2013, to November 19, 2014.

Results

Participation and Final Analysis Sample

A total of 112 314 individuals (95.3% of 117 907 with acuity measurement) could be reliably assigned to a visual function category (eFigure 1 in the Supplement). Of these, 61 169 participants (54.5%) were female, mean (SD) age was 56.8 (8.1) years, and 111 914 people (99.6%) lived in England. Five hundred sixty-four individuals were not tested (ineligible or other reason) and 1506 had both eyes tested, but the results were unreliable (eFigure 1 in the Supplement). There was insufficient information for visual acuity categorization for 3523 participants who had 1 eye tested. A total of 759 participants (0.7%) had visual impairment or blindness, and an additional 25 678 individuals (22.9%) had reduced vision in 1 or both eyes. Of 248 participants who self-reported VI in the untested eye, 195 people (78.6%) had good acuity (logMAR, 0.3 or better; Snellen equivalent, 6/12 or better) and 33 participants (13.3%) had reduced acuity (logMAR, worse than 0.3; Snellen equivalent, worse than

Table 2. Demographic, Socioeconomic, and Health Variables

Variable	Original Variable	Derived Variable[a]
Age	Age at recruitment	Age groups: 40-49, 50-59, and 60-73 y
Sex	Male or female	
Townsend Index[18]	Based on 4 area-based census variables	Continuous scale, range −6 to +10 (higher scores indicate greater deprivation)
Disability allowance[19b]	Governmental financial assistance for disability based on medical assessment	Governmental financial support for those with chronic illness; either no allowance or attendance and/or disability allowance
Attendance allowance[19b]	Governmental financial assistance for personal home care for those >65 y based on medical assessment	
Ethnicity	Reported in 21 categories under 6 main headings: white, mixed, Asian or Asian British, black or black British, Chinese, or other	6 Categories: white, mixed, Asian or Asian British, black or black British, Chinese, or other
Highest educational attainment[c]	No qualifications, O levels, A levels, or university/other professional qualification	
Accommodation type	House, apartment, or mobile/temporary accommodation[d]	Household structure: single-person, ≥2 individuals in household, sheltered accommodation, or care home
No. in household[e]	1, 2 or ≥3	
Mean total household income before tax, £[e,f]	<18 000, 18 000-30 999, 31 000-51 999, 52 000-100 000, or >100 000	Mean total income, <18 000 vs ≥18 000
Employment status	Employed, unemployed, retired, home maker, unpaid work, student, or unable to work	
Occupation category	Categories for job code based on the 9 top hierarchy job codes, from managers and senior officials to elementary occupations[g]	
General health	Self-rating as excellent, good, fair, or poor	
Mental health	Response to, "Have you ever seen a GP/psychiatrist for nerves, anxiety, tension, or depression?" (yes or no)	

Abbreviation: GP, general practitioner.

[a] If original variable was recategorized; no listing indicates that the original variable was unchanged.

[b] Data were not collected on UK certification for sight impairment/severe sight impairment, which enables government-provided financial assistance to those with severe sight loss. Thus, we used data collected on disability and attendance allowances, which provide governmental financial assistance for those with disability as assessed by a medical examination.[19]

[c] O levels indicate state school examinations at age 16 years; A levels, state school examinations at age 18 years.

[d] Trailer, sheltered accommodation, or residential care home.

[e] Question not asked if accommodation type reported as sheltered accommodation or care home.

[f] Average conversion rate from pounds to US dollars between June 2009 and July 2010 was £1 = $1.5814.

[g] From the standard occupation classification (2003) index (eTable 1 in the Supplement).[20]

6/12). These individuals were more likely to be male and of poorer social position than were those included in the analysis sample. Based on UK Census 2011 data (https://www.nomisweb.co.uk/census/2011), although the ethnic composition of UK Biobank is comparable to that of the general UK population, the analysis sample was older (participation increased with age), had fewer men, was more affluent, and had higher levels of education. Thus, the distribution of visual function (Table 1) cannot be extrapolated as precise population prevalence estimates. The distribution of all demographic, socioeconomic, and health variables by visual function category is presented in eTable 2 in the Supplement.

Sociodemographic Factors Associated With Visual Function

As reported in **Table 3**, VI across the acuity spectrum was consistently and independently associated with increasing age, female sex, and a worse deprivation score. The risk of VI rose with decreasing levels of educational qualification. Individuals in any black or minority ethnic group were more likely to have impaired visual function compared with white persons. Gradients were observed in these associations with social determinants of health within each visual function category. Comparison of these associations across visual function categories showed some gradient effects. For example, the increased risk of VI for persons without educational qualifications ranged from 1.29 (95% CI, 1.25-1.33) for unilateral near-normal vision to 1.99 (95% CI, 1.33-2.96) for bilateral SVI or blindness.

Refractive Error, Optical Correction, and Visual Function

Overall, 99 070 of 111 863 participants (88.6%) reported wearing eyeglasses or contact lenses for correction of distance, near vision, or both forms of VI. Of participants with no optical correction, 12 570 of 12 793 individuals (98.3%) had autorefraction, which suggested that fewer than 11% of the sample had an uncorrected refractive error (ie, 1.2% of all participants). Specifically, 749 people (6.0%) had myopia (mean SEQ, lower than −1 D) and 595 individuals (4.7%) had hypermetropia (mean SEQ, higher than +1 D). Having a refractive error but no optical correction was associated independently with younger age, male sex, increasing deprivation, and nonwhite ethnicity.

Visual Function and Socioeconomic Outcomes

Reduced visual function was independently associated with increased risk of being unable to work and being unemployed; individuals in the most severe category (VI/SVI/blindness) had 3 times the risk of being unable to work and twice the risk of being unemployed. Even those with only mildly reduced vision in 1 eye were disadvantaged (**Table 4** and eFigure 2 in the Supplement). Among participants with paid employment, impaired visual function was independently inversely associated with lower occu-

Table 3. Associations Between Sociodemographic Factors and Visual Function Category[a]

Variable	Adjusted RR (95% CI)				
	Unilateral		Bilateral		
	Near Normal[b]	VI[c]	Near Normal	Socially Significant VI	VI[c]
Sex					
Male	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]
Female	1.10 (1.06-1.14)	1.03 (1.00-1.05)	1.18 (1.09-1.28)	1.09 (1.01-1.16)	1.15 (1.03-1.29)
Increasing age, y	1.05 (1.04-1.05)	1.04 (1.03-1.05)	1.07 (1.06-1.08)	1.05 (1.05-1.06)	1.03 (1.01-1.04)
Age group, y					
40-49	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]
50-59	1.83 (1.73-1.93)	1.86 (1.69-2.03)	2.17 (2.03-2.32)	2.26 (1.93-2.66)	1.34 (1.06-1.70)
60-73	2.48 (2.30-2.68)	2.29 (1.97-2.67)	3.53 (2.96-4.22)	3.02 (2.72-3.36)	1.81 (1.29-2.54)
Ethnicity					
White	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]
Mixed	1.21 (1.00-1.46)	1.02 (0.87-1.20)	1.19 (0.57-2.41)	0.90 (0.46-1.78)	1.81 (1.27-2.59)
Asian/Asian British	1.47 (1.27-1.71)	1.32 (1.19-1.48)	2.39 (1.71-3.15)	2.05 (1.83-2.30)	1.99 (1.39-2.85)
Black/black British	1.47 (1.31-1.64)	1.29 (1.18-1.41)	2.27 (1.80-2.71)	2.46 (2.13-2.85)	1.82 (1.28-2.58)
Chinese	1.63 (0.96-2.77)	1.73 (1.16-2.59)	2.46 (1.08-5.20)	2.17 (1.44-3.28)	1.26 (0.41-3.91)
Other	1.45 (1.15-1.83)	1.26 (1.12-1.42)	2.06 (1.51-2.69)	1.62 (0.97-2.71)	2.47 (1.82-3.36)
Townsend Index[d]	1.03 (1.02-1.04)	1.04 (1.03-1.05)	1.04 (1.02-1.06)	1.08 (1.07-1.09)	1.10 (1.07-1.14)
Qualifications[e]					
Higher level	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]
A level	1.10 (1.07-1.13)	1.10 (1.04-1.18)	1.20 (1.06-1.37)	1.14 (0.95-1.38)	1.24 (0.84-1.83)
O level	1.13 (1.09-1.16)	1.09 (1.06-1.13)	1.22 (1.11-1.33)	1.28 (1.07-1.53)	1.26 (1.14-1.38)
None	1.34 (1.25-1.44)	1.29 (1.25-1.33)	1.81 (1.44-2.28)	1.86 (1.69-2.04)	1.99 (1.33-2.96)

Abbreviations: RR, risk ratio; VI, visual impairment.

[a] Comparing each visual function category with bilateral normal-acuity, logMAR 0.2 or better (Snellen equivalent, 6/9.5 or better) in 110 134 individuals.

[b] Estimates adjusted for all factors in the table (age as continuous variable), and variance adjustment for test center.

[c] Includes moderate VI, severe VI, and blindness.

[d] Higher scores indicate greater deprivation.[18]

[e] O levels indicate state school examinations at age 16 years; A levels, state school examinations at age 18 years.

Table 4. Associations Between Visual Function and Employment, Occupation Category, Household Income, and Household Structure

Visual Function Category	Adjusted RR (95% CI)					
	Employment Status[a]		Lower-Grade Occupation Category[b]	Lowest Income Band[c]	Household Structure[d]	
	Unable to Work	Unemployed			Single Person	Sheltered Accommodation or Care Home
Bilateral normal	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]
Unilateral near normal	1.22 (1.07-1.39)	1.14 (1.02-1.27)	1.05 (1.02-1.08)	1.21 (1.13-1.29)	1.08 (1.04-1.11)	1.31 (1.01-1.71)
Unilateral VI	1.39 (1.29-1.50)	1.17 (1.13-1.21)	1.06 (1.01-1.10)	1.16 (1.11-1.22)	1.13 (1.07-1.19)	1.53 (1.15-2.05)
Bilateral near normal	1.85 (1.35-2.54)	1.10 (0.68-1.77)	1.13 (1.01-1.27)	1.42 (1.36-1.49)	1.15 (0.96-1.37)	1.51 (1.13-2.01)
SSVI	1.65 (1.30-2.08)	1.55 (1.31-1.84)	1.24 (1.09-1.41)	1.62 (1.35-1.95)	1.24 (1.10-1.39)	2.47 (1.72-3.55)
VI/SVI/blind	3.48 (2.57-4.72)	1.91 (1.33-2.76)	1.35 (1.12-1.63)	1.58 (1.27-1.97)	1.28 (1.02-1.61)	3.73 (2.03-6.84)

Abbreviations: RR, risk ratio; SSVI, socially significant visual impairment; SVI, severe visual impairment; VI, visual impairment.

[a] Multinomial regression with reference category (employed). Risk ratios were adjusted for sex, age, ethnicity, Townsend Index,[18] and educational qualifications.

[b] Ordinal logistic regression – 9 categories of job description (standard occupational classification top-level categories). Estimates were adjusted for sex, age, ethnicity, Townsend Index, and educational qualifications.

[c] Logistic regression comparing individuals in the lowest income band (less than £18 000) with those in all other income bands combined (as reference). Estimates were adjusted for sex, age, ethnicity, Townsend Index, and educational qualifications, with additional adjustment for number of household members. Mean total household income was not requested for those in sheltered accommodation or care home and was missing for 15 089 of 110 134 (13.7%) participants. A higher proportion of those with VI had missing income data. The proportion increased from 13.1% of individuals with bilateral normal vision to 20.5% of those with SSVI or VI.

[d] Multinomial regression with reference category (≥2 people). Risk ratios were adjusted for sex, age, ethnicity, Townsend Index, and educational qualifications.

pational grade, with the risk increasing steadily across the spectrum of impairment. Impaired visual function was independently inversely associated with mean total household income as well as with an increased risk of living alone or living in sheltered accommodation or a residential care home, with a gradient across the acuity spectrum (Table 4).

Table 5. Associations Between Visual Function and General and Mental Health Outcomes and Disability/Attendance Allowance

Visual Function Category	Adjusted OR (95% CI)[a]			
	Poorer Rating of General Health	Sought Care for Mental Health[b]		Disability/ Attendance Allowance
		From General Practitioner	From Psychiatrist	
Bilateral normal	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]
Unilateral near normal	1.08 (1.05-1.11)	1.00 (0.97-1.04)	1.05 (0.95-1.16)	1.20 (1.01-1.31)
Unilateral VI	1.10 (1.06-1.15)	0.95 (0.93-0.97)	0.99 (0.95-1.04)	1.41 (1.29-1.54)
Bilateral near normal	1.12 (0.94-1.35)	0.99 (0.92-1.07)	1.14 (0.95-1.38)	1.64 (1.25-2.16)
SSVI	1.09 (0.93-1.27)	0.90 (0.83-0.98)	1.12 (1.04-1.20)	1.80 (1.45-2.23)
VI/SVI/blind	1.44 (1.29-1.61)	1.23 (1.02-1.48)	1.39 (1.07-1.79)	4.18 (3.53-4.94)

Abbreviations: OR, odds ratio; SSVI, socially significant visual impairment; SVI, severe visual impairment; VI, visual impairment.

[a] All estimates were adjusted for sex, age, ethnicity, Townsend Index,[18] and educational qualifications. Ordinal regression was used for general health rating; logistic regression was used for mental health and disability/attendance allowance outcomes.

[b] Included nerves, anxiety, tension, and depression.

Impaired Visual Function, Education, and Social Position

In the subgroup analysis restricted to individuals with higher educational qualifications, impaired visual function was associated independently with an increased risk of being unable to work, unemployed, and in a lower occupational category as well as having a lower household income (eTable 3 in the Supplement). Gradients in effect sizes across the acuity spectrum were observed but less consistently than in the full group analyses reported above.

Visual Function and Health Outcomes

In the adjusted model presented in **Table 5**, impaired visual function was associated with poorer self-reported general health. Those in the VI/SVI/blind category were 44% more likely than were those with normal vision to self-report poorer health and were also more likely to have ever visited a general practitioner or psychiatrist for common mental health conditions; individuals with socially significant VI were more likely to have visited a psychiatrist.

Of 109 172 participants with information on governmental financial assistance, 4537 persons (4.2%) were receiving assistance as a disability or attendance allowance. Those in the VI/SVI/blind category were more than 4 times more likely to be receiving this assistance than were those with normal vision, with a gradient of association with all levels of impaired function. These associations are likely to reflect impaired visual function in association with other disabling disorders since they remained statistically significant after adjusting for income.

Discussion

We report a novel, large-scale investigation of the relationship between social position and visual health (ie, full continuum of visual function) as well as the association between visual function and key general health and socioeconomic outcomes in a contemporary adult population in the United Kingdom. Of the population analyzed, 23.0% had real-life impaired visual function. We demonstrate that visual health is associated with known key social determinants of health[10,11] acting independently in the axes of social differentiation captured by age, sex, ethnicity, area or community-based deprivation, and educational experience and with a trend across the full spectrum of visual acuity. All-cause impaired visual function, a functional outcome of diverse processes analogous to all-cause mortality, was independently associated with adverse outcomes relating to employment, occupation, economic status, and self-reported general and mental health, with a gradient of increasing severity from the mildest impairment affecting only 1 eye to bilateral blindness.

Although it is a unique bioresource,[14] UK Biobank study has limitations. Because it is not a random subsample of the UK population, frequency and distribution cannot be interpreted as prevalence. The frequency of VI and blindness was lower than what might have been anticipated,[9,17,21-24] reflecting nonrandom recruitment, exclusion by protocol of some participants, and exclusion of other individuals without visual acuity data for both eyes that are necessary for categorization of visual status. Thus, we report indicative minimum estimates of frequency. The limited number of participants in the worst categories of VI/SVI/ blindness precluded conclusive analysis of differences between these groups. Nevertheless, the very large size as well as diversity and number of details of the study sample, combined with the low levels of missing data, allowed robust investigation. Although the cross-sectional design precludes elucidation of temporal relationships (eg, between visual function and education, employment, and occupational categories), which is necessary to confirm causality, the findings nevertheless serve to identify the existence of patterns of inequality and delineate new hypotheses for testing in longitudinal research to identify pathways of action.[25]

The epidemiologic literature[22,26-28] on visual function in adults has understandably principally addressed the worst end of the spectrum (ie, low vision and blindness), which is known to be associated with belonging to an ethnic minority and having lower socioeconomic status. Longitudinal research on the 1958 British birth cohort by our group[17,24] provided the conceptual basis for the present study that has exploited the greater scale and diversity of UK Biobank, albeit using cross-sectional data, to identify and understand current patterns of social inequalities in visual health across the spectrum from normal vision to VI, SVI, and blindness.

Only 76.5% of the adults in the present study had normal habitual vision in both eyes. The rest of the population had impaired visual function, which even in its mildest form (eg, affecting only 1 eye or still exceeding the minimum threshold for driving) was associated with an increased risk of adverse social and health outcomes. This finding flags a significant burden of underrecognized and/or preclinical disability,[29] which may be masked by adaptive

strategies (eg, avoiding driving) that may themselves lead to inequalities of opportunity and go unrecognized without acuity testing during, for example, general health or well-being checks. In addition, we have demonstrated dose-response–type gradients starting with mildly reduced visual function, with any level of bilateral visual impairment being associated with greater disadvantage than any level of unilateral impairment. Although there appear to be no studies directly comparable to ours, the broader literature[10,11,13] on social determinants and health inequalities supports our hypothesis that such associations are likely to exist worldwide, although the scale will vary.

From a health policy perspective, our findings highlight the value of shifting thinking to overall population visual health and away from exclusive consideration of visual impairment. Our findings point to the antecedents of inequalities in visual health and highlight the potential for widening of gaps over time, particularly with an aging population. We suggest that visual function needs to be embedded better in public health structures and processes as a key sensory health indicator that is routinely considered, both independently and as part of all-cause morbidity, as both a risk factor and health outcome measure. Inclusion of visual health indicators within measures routinely monitored in health services, such as in the United Kingdom within the National Health Service Outcomes Framework,[30] would facilitate alignment of strategies against avoidable VI,[5,6] with the broader key initiatives tackling general health inequalities.[11,13,31]Such inclusion would add mutual value and improve cost-effectiveness; for example, smoking cessation or uptake prevention strategies may prove valuable in preventing blindness[32] as well as reducing mortality, and citing the risk to visual health could be a powerful addition to general public health and health promotion campaigns.[33] In tandem, eye- and vision-specific strategies addressing diseases with known sociodemographic correlates, such as glaucoma[34] and diabetic eye disease,[35] through targeted approaches to improving early detection, including formal screening programs, could routinely include metrics of social position to good effect within treatment and visual rehabilitation protocols.

There is increasing worldwide attention to refractive error as a readily remediable cause of impaired vision when undetected or uncorrected due to limited access to or use of services or affordability of eyeglasses.[36,37] Because uncorrected refractive error was present in only 1.2% of the participants in our study, it is not a major contributor to the findings but illustrates the complexities and challenges of condition-specific approaches. There is limited and inconsistent literature[38] indicating that differential uptake of free sight tests or free eyeglasses can paradoxically widen rather than eliminate inequality gradients.[39] In developing new strategies, it will be important to remember that the determinants of visual health may differ from the determinants of inequalities in visual health and that these factors may work in opposing directions.

Conclusions

We propose that the conceptual framework for thinking about vision that focuses on impairment rather than health, together with extant gaps in knowledge, are hindering the development and application of proportionate universalism[11] (ie, evidence-based policies and interventions) to achieve higher levels of visual health and improve life chances of the whole population while simultaneously reducing the magnitude and gradient of inequalities. Evidence from other clinical disciplines supports the potential gain, with relatively little additional effort, that may be achieved with routine inclusion of visual function in individual health assessments of patients at risk for visual impairment and from routine inclusion of vision and eye health in its broadest sense in existing national and international initiatives addressing social determinants of disease and tackling health inequalities.[11,13] Longitudinal research delineating mechanisms and pathways, including consideration of both specific eye diseases and visual neurodevelopment and cognition, is needed to develop new targeted strategies.

ARTICLE INFORMATION

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